National
Qualifications
2017

2017 Engineering Science

Higher

Finalised Marking Instructions

General marking principles for Higher Engineering Science

This information is provided to help you understand the general principles you must apply when marking candidate responses to questions in this Paper. These principles must be read in conjunction with the detailed marking instructions, which identify the key features required in candidate responses.

(a) Marks for each candidate response must always be assigned in line with these general marking principles and the Detailed Marking Instructions for this assessment.

(b) Marking should always be positive, ie marks should be awarded for what is correct and not deducted for errors or omissions.

(c) If a specific candidate response does not seem to be covered by either the principles or detailed Marking Instructions, and you are uncertain how to assess it, you must seek guidance from your Team Leader.

(d) Where a candidate makes an error at an early stage in a multi-stage calculation, credit should normally be given for correct follow-on working in subsequent stages, unless the error significantly reduces the complexity of the remaining stages. The same principle should be applied in questions which require several stages of non-mathematical reasoning.

(e) All units of measurement will be presented in a consistent way, using negative indices where required (eg ms−1). Candidates may respond using this format, or solidus format (m/s), or words (metres per second), or any combination of these (eg metres/second).

(f) Answers to numerical questions should normally be rounded to an appropriate number of significant figures. However, the mark can be awarded for answers which have up to two figures more or one figure less than the expected answer.

(g) Unless a numerical question specifically requires evidence of working to be shown, full marks should be awarded for a correct final answer (including unit) on its own.

(h) A mark can be awarded when a candidate writes down the relevant formula **and** substitutes correct values into the formula. No mark should be awarded for simply writing down a formula, without any values.

(i) Credit should be given where a labelled diagram or sketch conveys clearly and correctly the response required by the question.

(j) Marks should be awarded regardless of spelling as long as the meaning is unambiguous.

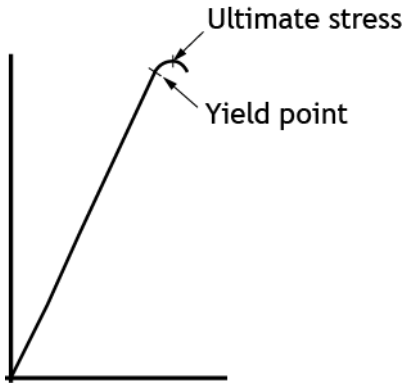
(k) Candidates may answer programming questions in any appropriate programming language. Marks should be awarded, regardless of minor syntax errors, as long as the intention of the coding is clear.

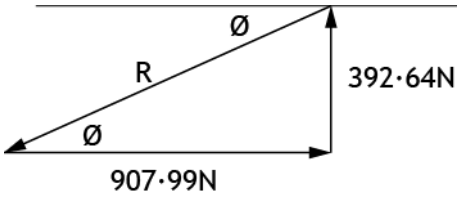
(l) Where a question asks the candidate to "explain", marks should only be awarded where the candidate goes beyond a description, for example by giving a reason, or relating cause to effect, or providing a relationship between two aspects.

(m) Where separate space is provided for rough working and a final answer, marks should normally only be awarded for the final answer, and all rough working ignored.

Detailed marking instructions for each question

Section 1

Question			Expected answer(s)	Max mark	Additional guidance
1.	(a)		The material behaves in an elastic manner – it stretches and then returns to its original length after the load is removed.	**1**	
	(b)		The material behaves in a plastic manner, it becomes permanently deformed – it stretches beyond the plastic limit until it fails/breaks.	**1**	Mark awarded for mentioning that the material will not return to its original shape.
	(c)			**2**	1 mark for each correct annotation Yield point – This should be anywhere between the top of the straight line and the ultimate stress point, if it is out with these two points, no marks.

Question			Expected answer(s)	Max mark	Additional guidance
2.			$\Sigma F_V = 0$ $R_V = 1100 \sin 51 - 510 \sin 65 = 392.64$ N	**4**	1 mark for magnitude
			$\Sigma F_H = 0$ $R_H = 1100 \cos 51 + 510 \cos 65 = 907.79$ N		1 mark for magnitude
					
			$R = \sqrt{(392.64^2 + 907.99^2)} = 989$ N		1 mark for value with unit
			Tan Θ = 392.64/907.99 => Θ = 23.4°		1 mark for value with unit

Question			Expected answer(s)	Max mark	Additional guidance
3.			Uniformly distributed load: 2.5 x 7.7 = 19.25 kN @ 3.85m midpoint Moments about B: (6.1 x 4.0 sin71) + (19.25 x 3.85) = 7.7 R_A 23.07 + 74.11 = 7.7 R_A R_A = 97.18/7.7 = 12.6 kN	**3**	1 mark for value 19.25 kN 1 mark for substitution 1 mark for final answer with unit
4.	(a)		I_{LDR} = 0.7/610 = 1.15mA	**1**	1 mark for correct answer with unit. Accept 1.148mA/1.1mA/1mA. 1.2mA not acceptable.
	(b)		I_{VR} = 5.3/3300 = 1.6mA	**1**	1 mark for correct answer with unit. Accept 2mA/1.61mA/0.0016A/0.00161A
	(c)		I_b = 1.6 – 1.15 = 0.45mA	**1**	1 mark for correct answer with unit. FTE.

Question			Expected answer(s)	Max mark	Additional guidance
5.	(a)		Taxi drivers may lose their jobs as the cars will be able to do their jobs without them. Long distance transportation would be cheaper as there would be no drivers needing breaks. Since you need to brake and accelerate less, you will use significantly less fuel, saving you money.	**2**	Any other suitable answer.
	(b)		Accidents are less likely as human errors are reduced resulting in people feeling safer/less anxious on the road. Disabled people will have greater autonomy. People will not be at risk of drunk driving as the car will take them home. Car journeys will become more sociable as the "driver" can fully interact with the passengers. People without a driving licence can now get around in their own car making them more independent to go out of the house to leisure activities etc.	**2**	Any other suitable answer. There must be a social impact, saying less car accidents or unemployment is not enough.

Question			Expected answer(s)	Max mark	Additional guidance
6.	(a)		MOSFETs – size of gate voltage BJTs – size of base current MOSFET is voltage controlled device with its operation controlled by gate-source voltage (V_{GS}) BJT is a current controlled device with its operation controlled by base current.	**1**	1 mark for identifying BOTH factors
	(b)		MOSFETs can handle larger currents therefore drive larger output devices. MOSFETs have lower power/energy consumption and therefore more efficient than BJTs. BJTs are preferred for low current applications, while MOSFETs are for high power functions.	**1**	Cause and effect for 1 mark.

Section 2

<table>
<tr><th colspan="3">Question</th><th>Expected answer(s)</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td>7.</td><td>(a)</td><td>(i)</td><td>$Z = A \oplus (\overline{B}.C)$

Or

$Z = \overline{A}.\overline{B}.C + A.\overline{\overline{B}.C}$

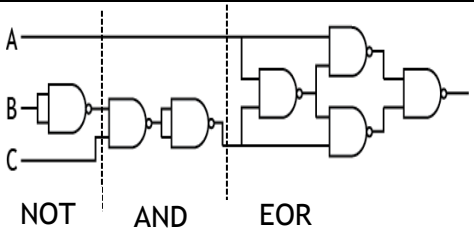
Or

$Z = \overline{A}.\overline{B}.C + A.\overline{B}.\overline{C} + A.B.\overline{C} + A.B.C$</td><td>3</td><td>1 mark for exclusive OR
1 mark for NOT B
1 mark for B AND C

Brackets are optional.

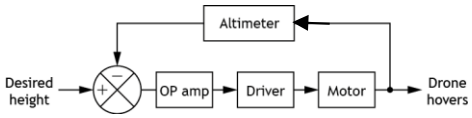
1 mark for each correct ABC
1 mark for OR

1 mark – 2 correct
2 marks – 4 correct
1 mark - OR</td></tr>
<tr><td></td><td></td><td>(ii)</td><td><table><tr><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>Z</th></tr><tr><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td></tr><tr><td>0</td><td>0</td><td>1</td><td>1</td><td>1</td><td>1</td></tr><tr><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td></tr><tr><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td><td>1</td><td>1</td><td>0</td></tr><tr><td>1</td><td>1</td><td>0</td><td>0</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>1</td></tr></table></td><td>3</td><td>1 mark for each correct column (D, E, Z)

FTE should apply.</td></tr>
<tr><td></td><td></td><td>(iii)</td><td> 
</td><td>3</td><td>1 Mark for NOT
1 Mark for AND
1 Mark for EOR</td></tr>
</table>

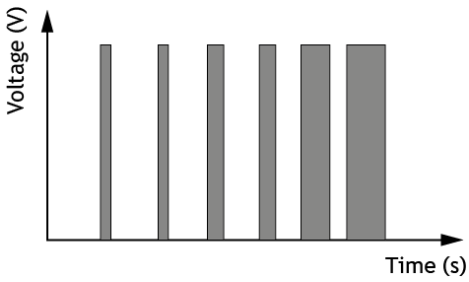
Question			Expected answer(s)	Max mark	Additional guidance
7.	(b)		A descriptive answer based on topics such as… Specialist skills: Designing electronic sub-systems eg. Sensing circuits Plan programs Design interfaces Test programme function Design switching circuits Write code Specialist Knowledge: Understand how microcontrollers function Op-amp electronic control systems Understand interfacing Function of a relay Programming knowledge. Energy audits.	**2**	Answer should not be a simple statement.

Question			Expected answer(s)	Max mark	Additional guidance
7.	(c)	(i)	Choosing of manufacturing methods that are eco-friendly to reduce the environmental impact. Choosing of materials that are eco-friendly. Ie sustainable. The waste management for the construction. Introduction of low carbon technologies to reduce carbon footprint. Adapting the design to limit the impact on the environment eg soil/water/wildlife/plants etc.	**2**	Must be related to the chemical plant being environmentally friendly. 1 mark for brief response 2 mark for detailed response
		(ii)	Positive Impact • Reduced tax • Less waste disposal costs • More sustainable • Energy costs lowered • Benefit from government incentives • Increased sales as products are more environmentally friendly Negative Impact • Initial capital costs to meet legislation, • more energy efficient building methods, • sustainable materials, • energy efficient materials.	**2**	All answers must be descriptive and not statements. Must have an economic aspect. Must be related to the chemical plant being environmentally friendly. Simply writing initial cost, as a negative impact, is not enough. The response must give indication of what areas the initial cost will cover. Eg insulation, water reclamation systems, heat recycling etc.

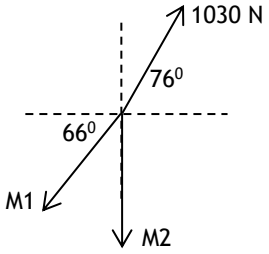
Question			Expected answer(s)	Max mark	Additional guidance
8.	(a)			**3**	1 mark for error detector symbol (must show negative error) 1 mark for driver/transistor/MOSFET 1 mark for feedback sensor with correct arrows
	(b)		Ib = 97/210 = 0.46mA Vr = 0.46mA x 1200 = 0.55V V1 = 0.55 + 0.7 = 1.25V	**3**	1 mark for correct value of Ib Accept 0.462mA 1 mark for calculating Vr 1 mark for V1 with unit
	(c)		Input to final inverting amp is -1.25. -1.25 = -10k (V_{hover}/20k) Vhover = 2.5V	**2**	1 mark for correct substitution (1.25 taken from b) -1.25 = -(20k/10k) x V_{hover} 1 mark for answer with unit
	(d)		1.6 = (40k/10k) x (3-V_{alt}) V_{alt} = 2.6 V	**2**	1 mark for substitution 1 mark for correct answer with unit

Question			Expected answer(s)	Max mark	Additional guidance
8.	(e)		As desired height is increased the output of the difference amplifier will increase positively. This produces a larger input to the transistor which generates a larger current in the motor. As the motor speeds up the drone will climb closer to the desired height. As it does the altimeter signal will increase, getting closer to the desired voltage. As it gets closer the output of the difference amp reduces and the motor speed reduces.	**3**	Any three statements that clearly reference the circuit **or** describe the action of the motor/drone.
	(f)		Rldr = 600 Ω R/600 = 2.4/3.6 R = 400 Ω	**2**	1 mark for correctly reading Rldr with unit Accept value between 600-650Ω 1 mark for correct value of R with unit.

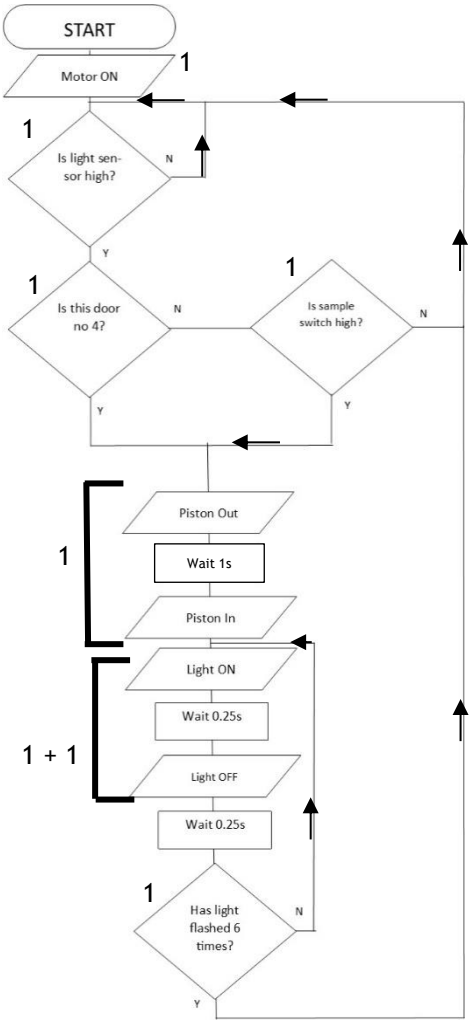
Question			Expected answer(s)	Max mark	Additional guidance
9.	(a)	(i)	Area = (30 x 5 x 2) + (20 x 5) = 300 + 100 = 400 mm^2 $\sigma = F/A = 900/400$ = 2.25 Nmm^{-2}	**2**	1 mark for correct area (units not required, not final answer) 1 mark for final answer with units Accept 2.3 Nmm^{-2}
		(ii)	E = 196 $kNmm^{-2}$ $E = \sigma/\varepsilon$ $\Rightarrow \varepsilon = \sigma/E = 2.25/196x10^3$ = 0.0000115	**2**	1 mark value from data booklet 1 mark final answer (no units) Accept 0.000011 If a unit is given, no mark.
		(iii)	F.O.S. = U.T.S/W.S. F.O.S. = 430/2.25 = 191	**2**	1 mark for UTS from data book 1 mark for final answer Accept 187 if 2.3 Nmm^{-2} is used If unit is given, no mark.
		(iv)	Could be high due to consequence of failure which would involve risk to human life. Over engineered; revise material choice, size of cross-sectional area for material to reduce costs.	**1**	1 mark for a comment which says why it is an appropriate value. Candidates response should match F.O.S. value found in (iii). If F.O.S. value is low in (iii) then answer should be not appropriate due to the risk to human life.

Question			Expected answer(s)	Max mark	Additional guidance
9.	(b)	(i)	T=Fr = 8 x 130 x 7 = 7280 Nm	**2**	1 mark for substitution 1 mark for final answer with units Accept 7300 Nm
		(ii)	n = (18/3)/60 = 0.1 P = 2πnT = 2π x 0.1 x 7300 = 4580 W (4.58 kW)	**2**	1 mark for correct substitution 1 mark for final answer with units Accept 4600 W/4.6 kW
		(iii)	P=IV = 30 x 240 = 7200W η = Pout/Pin x 100 = 4.58/7.2 x 100 = 63.6% or 0.636	**2**	1 mark for calculating P (no units required) 1 mark for final answer Accept 0.64 / 64% If unit is given for decimal answer, no mark.
	(c)			**2**	1 mark for correctly labelled axes. 1 mark for clearly increasing MARK/SPACE ratio as time increases. Candidate must clearly show: • gaps(SPACE) getting smaller and the columns getting wider(MARK), • gaps getting smaller and the columns staying the same, • gaps staying the same and the columns getting wider. Must have at least 6 pulses.

Question			Expected answer(s)	Max mark	Additional guidance
9.	(d)		<u>Verticals</u> M2 Cos45° + M1 Cos69° = 1030 Cos59° [M2 × 0·707] + [M1 × 0·358] = 530·49 <u>Horizontals</u> M2 Sin45° + M1 Sin69° =1030 Sin59° [M2×0·707] + [M1×0·934] = 882·88 M1×0·358 + M2×0·707 = 530·49 M1×0·934 + M2×0·707 = 882·88 M2x0.707 = 530.49 – M1 x 0.358 M2x0.707 = 882.88 – M1 x 0.934 M1 530.5-0.358M1 = 882.9 -0.934M1 0.934M1 – 0.358M1 = 882.9 – 530.5 0.576M1 = 352.4 M1 = 352.4 / 0.576 **M1 = 612 N** M2 M2x0.707 = 530.49 – M1 x 0.358 M2 = 530.49 – (612 x 0.358) / 0.707 **M2 = 440.0 N** **Alternative answer next page**	**5**	1 mark for substitution 1 mark for substitution 1 mark for substitution 1 mark final answer with unit (M1) 1 mark final answer with unit (M2)

Question			Expected answer(s)	Max mark	Additional guidance
9.	(d)		**Continued.** Alternative Method  $31^0+45^0 = 76^0$ $21^0+45^0 = 66^0$ $45^0+45^0 = 90^0$ $\sum F_H=0$ 1030 cos 76 – M1 cos 66 = 0 M1 = 612 N $\sum F_V=0$ 1030 sin 76 – M1 sin 66 – M2 = 0 M2 = 440.0 N		1 mark for all 3 angles 1 mark for substitution 1 mark final answer with unit (M1) 1 mark for substitution 1 mark final answer with unit (M2)

Question			Expected answer(s)	Max mark	Additional guidance
10.	(a)	(i)	• Pilot air is sent to valve 8 cutting of the pilot air to sent from valve 8 to valve 5. • Valve 2 sends pilot air to valve 5 outstroking cylinder A. • When cylinder A is fully outstroked, valve 3 is actuated sending pilot air through valve 9 which actuates valve 6 outstroking cylinder B. • This causes cylinder B to actuate roller trip valve 4 sending pilot air back to the 5/2 valve 6 instroking cylinder B. • Actuating Valve 4 cuts the air supply to valve 9 which stops cylinder B outstroking so that it now instrokes. • When cylinder B has instroked, roller trip valve 7 is actuated sending pilot air to valve 8 which actuates the 5/2 valve 5 causing cylinder A to instroke resetting the system.	**6**	1 mark for each statement
		(ii)	1. Solenoid actuator -replacing the push button on valve 2. This will cause the system to be operated automatically as it can be connected to electronic interfaces. 2. A reservoir and restrictor- between valve 4 and 6. This will create a time delay in the circuit before valve 6 starts the instroking process.	**6**	3 marks available to each point. 1 mark for correct component 2 marks for explanation (location in circuit with reason) This will delay cylinder B and cylinder A from instroking. N.B. if candidate answers the wrong way round, give credit appropriately.

Question			Expected answer(s)	Max mark	Additional guidance
10.	(b)			**8**	1 mark – Motor On 4 marks – Decision box with correct Y/N directions (1 mark each decision) 1 mark Piston Out/Wait 1s/In 1 mark Light On/Wait/Off 1 mark for light flashing in correct ratio (wait/delay 0.25s) N.B. If a candidate uses the wrong symbol type then no mark, if they repeat the error for the same symbol allow FTE.

[END OF MARKING INSTRUCTIONS]